CHAPTER 10

Capital Needs for Modernization and Expansion

Contents

List of Tables

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Summary

The U.S. steel industry has a record of relatively low levels of capital expenditures, This record has been coupled with a history of decreasing capacity, decreasing technological competitiveness, very modest gains in productivity, and aging facilities. The industry frequently cites inadequate capital as the most critical barrier to the greater adoption of new technology, but the real issue is what its capital spending buys in terms of new technology and new capacity.

Although the industry's capital spending has had a downward trend during the past two decades in terms of real dollars spent on productive steelmaking facilities per tonne of steel shipped, it is also cyclical, Peaks occur every 7 to 8 years, and they follow peaks in net income by 1 or more years, The industry uses increasing amounts of capital for nonsteel expansion activities and continues to distribute relatively large cash dividends to stockholders, even when sales and profitability are depressed.

There are three routes to revitalizing the technological base of the industry: modernization and replacement; roundout or "brownfield" expansion of existing facilities; and new plant or "greenfield" construction. OTA's analysis of the minimum modernization and capacity expansion needs for the coming decade indicates that a cost-effective approach is to maximize the use of roundout expansion at existing integrated plants and to construct more electric furnace steelmaking facilities, particularly in nonintegrated companies producing a limited range of products. The high capital costs of greenfield integrated facilities based on the best available technology are not sufficiently offset by reduced production costs. This situation may change eventually if major technological changes are applied to integrated steelmaking.

The American Iron and Steel Institute (AISI) estimates that it will require $4.9 billion' annually to modernize and expand steelmaking capacity. OTA calculates that modernization and expansion could be achieved by spending approximately $3 billion annually over the next 10 years followed by large expenditures for new integrated facilities in the **1990's.** The industry scenario increases capital spending for productive steelmaking by 150 percent over the past decade's average; the OTA scenario increases it by approximately 50 percent. The AISI and OTA scenarios agree that approximately $2.2 billion annually will be needed for meeting regulatory requirements, nonsteel investments, and other increases in working capital. Total capital spending is thus $7.0 billion annually by industry estimate and $5.3 billion by OTA calculations.

Given the basic assumptions of this analysis, such as increased steel shipments and, hence, increased total revenues, to what extent can the industry meet its own capital needs? The industry has not provided an analysis of capital formation and cash flow. The OTA analysis of capital sources and needs points to a capital shortfall of at least $600 million annually through 1988, assuming 1978 levels of profitability, dividends, and nonsteel activities are maintained. This is considerably less than the deficits projected by the industry analysis. If modernization and expansion lead to a modest 2-percent saving

*Unless otherwise noted. all figures in this chapter are in 1978 dollars.

in production costs, then by 1988 return on equity could increase from the 1978 level of 7.3 percent to about 12 percent, and could provide a basis for more vigorous industry growth and expansion in the years beyond. The same reduction in production costs, coupled with a Federal policy that added approximately $600 million to the industry's cash flow, would increase the return on equity to almost 15 percent.

OTA finds that the international capital cost competitiveness of the domestic steel industry has suffered relative to Japanese and European steelmaker. Some reasons for this are outside the control of the industry, but other factors, such as design and equipment supplier choices, are within its control.

Three Ways to Modernize and Expand Capacity

Inadequate capital has probably hampered the adoption of new technology by the domestic steel industry. The rate of capital spending has declined during the last two decades, from an average of $36.3/tonne shipped during 1959-68 to $27. l/tonne during 1968-78. ' But this is not the entire picture. During the 1950-78 period, there was a cyclical pattern to the industry's capital spending, with peaks occurring every 7 to 8 years. Thus, in 1952, 1960, 1967, and 1975, the respective levels of capital expenditures were $45.9, $43.0, $46.4, and $40.5/tonne shipped. The spending peaks correspond to replacement rates of about 4 percent, compared with the more typical replacement rates for the past several decades of 2 or 3 percent. The peaks in capital spending follow peaks in net income by 1 or more years.[2]

A more fundamental issue is not when the capital spending occurs or even its level, but the extent to which it produces new technology and new capacity in the industry. Because the costs of steelmaking equipment and facilities have risen faster than the general level of inflation, capital expenditures buy less today than before. Table 127 compares changes in the steel equipment cost index with changes in other price and production cost indexes. Nominal inflation, shown by the consumer price index, has been less than that for equipment, energy, and labor costs indexes. Steel prices have increased at a lower rate than capital equipment costs but not significantly so for the past 5 years. This slowdown in equipment cost increases may be due to greater use of foreign-produced capital equipment, which has generally become available in the U.S. market at considerably lower costs than from domestic equipment manufacturers. Also, relatively low levels of replacement and plant additions may have reduced domestic demand for capital equipment and discouraged price increases.

As capital spending declined following the 1975 peak, so did domestic steel capacity.

Table 127.—Change in Steel Equipment Cost Index Versus Other Cost and Price Indexes

Index	Ratio for 1978- 1965	Ratio for 1978 – 1973
Steel equipment cost[a]	2.79	1.95
Consumer Price Index	2.07	1.47
Steel price index	2.61	1.90
Steel industry wages[b]	3.19	1.86
Metallurgical coal	7.28	3.26
Electrical power	2.71	2.11

aFrom *World Steel Dynarnamics,* April 1979, derived from ECSC data through 1976 and estimated by WSD thereafter
bBased on dollars per hour includlng fringe benefits, from the U.S. Department of Labor

ID. F. Barnett, "Capital Requirements for Modernization," Atlantic Economic Conference, October 1979. These values are for productive steelmaking and exclude spending for regulatory needs and nonsteel activities,

'Cyclic capital investment linked to cyclic profits has been cited as a cause of underinvestment, "As a result of this cyclical investment policy, the industry has not been able to replace its high-cost, outdated, inefficient, steelmaking capacity as fast as was necessary to remain competitive with foreign producers. " (R. S. Thorn, "The Trouble With Steel, " *Challenge,* July-August 1967.)

From 1977 to 1979, about 6.35 million tonnes, or 4 percent, of total raw steelmaking capacity was lost. The loss would have been greater were it not for considerable increases in electric furnace steelmaking capacity in both integrated and nonintegrated companies, which partially offset the closing of older integrated plants. Today's production capacity is about the same as it was in 1960, Because a significant percentage of steelmaking facilities are obsolete (see ch. 4), it is likely that in the near term, when demand for steel is expected to decline as a consequence of a general economic slowdown, the closing of older and obsolete plants will continue or increase,

Steel capital spending is generally for the purposes of modernization, brownfield, or greenfield expansion. These terms maybe defined as follows:

Modernization. —Traditionally, spending in this category has been directed at replacing unusable and wornout equipment in order to maintain the operating capacity of a plant. The terms maintenance and replacement are also used. A point of confusion is whether capital spending in this category is associated with capacity expansion. Some analysts assume that capacity does not increase when facilities are modernized, maintained, or replaced, Although it is true that these expenditures are not primarily intended to add capacity, improvements in technology and equipment design do result in increased capacity, generally because of higher yields; the replacement of ingot casting with continuous casting is an important example of such increases (see ch. 9). Also significant is the fact that with newer facilities it is possible to operate a plant at higher sustained rates of capacity utilization.

Because most steelmaking equipment is long-lived, it is reasonable to assume that by the time it is replaced, the new equipment, representing newer technology, will be more productive than the old. Thus, replacement is likely to involve capacity increase, unless as an economy measure the new equipment is selected purposely to keep capacity stable. In some cases, however, the capacity increase that new equipment makes possible may apply only to a particular step of the steelmaking process; it does not necessarily affect capacity for the entire plant and cannot always increase steel shipments from that plant. Steelmaking is a sequential process, and plant capacity levels will be constrained to the lowest capacity link in the sequence. But generally, capital spending for modernization either leads to significant improvements in capacity or sets the stage for future expansion by removing individual "bottlenecks" in the production process.

Roundout or Brownfield Expansion.—These terms have been used to describe capital spending that has as its main purpose increasing capacity in the total steelmaking operation. Both roundout and brownfield expansion occur on the site of an existing plant. One type of roundout is the installation of higher capacity equipment at one or more of the "bottleneck" steps that limit capacity for the whole plant. In some cases, plants are constructed and designed so as to anticipate future roundout; when roundout does occur, it is an add-on expansion, rather than a replacement. Brownfield expansion is a form of roundout, usually on a large scale, that involves better balancing of individual operations than a simpler roundout.[3] A radical form of brownfield expansion, theoretically possible but apparently not used or contemplated, is the tearing down of an existing plant and the construction of a new plant on the same site.

The chief limitation of roundout as a means of increasing capacity is that the basic technology and layout of a plant are maintained. Roundout costs less per net increase in capacity than new plant construction, but there will usually be fewer improvements in productivity and efficiency of inputs. A plant designed from the ground up, on the other hand, may use new types of equipment throughout and be designed to realize economies of scale. New plants also allow optimizing geographical location when markets and sources of

[3] J. C. Wyman, "The Steel Industry: An American Tragedy?" Faulkner, Dawkins, and Sullivan, February 1977.

raw materials have shifted. For example, access to major waterways is more important today than in previous decades, because more use is being made of domestic iron ores located far from major centers of steelmaking and ports of entry for imported ores.

The exact capacity increase that roundout makes possible is a significant issue. A Fordham University study in 1975 estimated that roundout could expand capacity for finished steel products by 11.8 million tonnes.[4] Inland Steel estimated that roundout potentially could expand product capacity by 14.5 million tonnes,[5] and its chairman has said that rounding out can satisfy the industry's growing needs, presumably at current import and demand growth levels, through the 1980's without the need to build new plants.[6] The chairman of National Steel has indicated that by 1985 roundout expansion could lead to a net increase of 4.5 million to 5.4 million tonnes of product capacity, assuming that the current rate of plant closings continues.[7] The chairman of Bethlehem Steel has noted that his company's 4.5-million-tonne/yr plant at Burns Harbor, Ind., was designed to accommodate expansion to 9.1 million tonnes.[8] An A. D. Little study based on extensive interaction with the industry stated that:

> Our calculations of capital requirements to achieve capacity expansion were based on our assessment of the types of facilities needed to add 40 million tons of capacity from the beginning of 1975 to 1983. We have assumed conservatively that this expansion could be achieved largely by "rounding out" of plants rather than building more expensive, new "greenfield" plants. The industry anticipates that 40 percent of this growth in capacity will be realized from the installation of new facilities, and that the balance will be accomplished by the modernization or "rounding out' of existing facilities.[9]

This study estimated that roundout expansion could produce 21.8 million tonnes of raw steel or 16.3 million tonnes of product capacity, a figure confirmed by at least one other study;[10] a third study resulted in rather large estimates of 27.2 million tonnes of product capacity expansion for the United States and 36.3 million tonnes for Japan.[11]

Greenfield Expansion.—This type of expansion involves building a new steel plant on a site not previously used for steelmaking. It is the highest cost approach to capacity expansion, especially if capital cost estimates for greenfield integrated plants include the cost of raw materials processing capacity. (There appears to be a consensus that the proper methodology is to include such costs, because that capacity is an integral part of the plant; given a choice, OTA capital cost estimates include the costs of raw material processing capacity.)

It is accepted that greenfield expansion provides the greatest opportunities for installing optimum new technology and plant layout and offers maximum production cost savings. These advantages, however, usually will not offset the large capital costs. Table 128 shows several comparisons of greenfield to roundout expansion. There is agreement that greenfield expansion cannot be justified, either on the basis of the price necessary to obtain an acceptable level of profitability or in terms of the net increase in costs. The case of energy conservation exemplifies this conclusion: by spending $1 l/tonne on retrofit equipment, a steel company could save 1.1 million Btu/tonne; a greenfield replacement of the same productive facilities could save 8 times that much energy, but it would cost at least 120 times as much to accomplish.[12] Given current policies and price levels, the capital and financial costs are too high relative to the benefits from the best available integrated steelmaking technology to favor greenfield expansion.

[4] Fordham University, "Financial Study of the U.S. Steel Industry, " August 1975.

[5] W. H. Lowe, "Capital Information in the Steel Industry, " *Proceedings of Steel* Industry Economics Seminar. AISI, March 1977.

[6] Fortune, Feb. 13, 1978, p. 129.

[7] Industry Week, June 11, 1979, pp. 186-188.

[8] Ibid.

[9] "Steel and the Environment: A Cost Impact Analysis, " A. D. Little, May 1975.

[10] E. Frank, quoted in Industry Week, May 15, 1978.

[11] H. G. Mueller, "Structural Change in the International Steel Market, " Middle Tennessee State University, May 1978.

[12] *Iron* Age, Nov. 12, 1979, p. 40.

Table 128.—Cost or Price Increases Required by Integrated Greenfield Expansion (dollars per tonne)

Source	Comparison basis	Greenfield	Roundout	Greenfield difference
Marcus[a]	Price-1 3°/0 return on equity 1st year	$541	$356	+ $185
	midlife	431	333	+ 98
	price- 12% discounted cash flow, *36%* debt midlife	526	366	+ 160
Republic Steel[b]	Price-15% return on investment	NA	NA	+ 165
COWPS[c]	Manufacturing costs	573	396	+ 177
Mueller[d]	Manufacturing costs	473	396	+ 77

NA = Not available
aP. Marcus, 'Steeling Against Inflation, ' Mitchell, Hutch Ins, May 1977.
b.W.J DeLancey, C.E.O. New *York Times,* June 181979
[c]Council on Wage and Price Stability "Prices and Controls in the U S Steel Industry, " 1977
dH.G. Mueller Structural Change in the International Steel Market, Middle Tennessee State University, May 1978

An excellent example of how roundout can be far more cost effective than new plant construction is the following case of blast furnace modifications. U.S. Steel Corp. paid $100 million for modifying a s-year-old blast furnace because it had failed to reach its designed capacity of 5,900 tonnes of iron daily;{ with the modifications it is expected to produce 6,800 tonnes daily. Assuming that 80 percent of the capacity has been reached, that the new furnace will operate 300 days/yr, and that the yield from blast furnace iron to finished steel is 70 percent, the cost of new finished steel capacity is just over $11 l/annual tonne. This is less than 10 percent of the cost per tonne for a green field integrated facility.

'"rhe *Wall Street Journal*, Feb. 14, 1980.

Capital Requirements for Modernization and Expansion

Calculating future capital requirements necessitates making a great number of assumptions about supply, demand, and unit costs, AISI has recently made a major study of capital requirements in the steel industry.[14] OTA believes the AISI study assumptions are reasonable and has used those assumptions and designed its scenarios so as to be comparable with the AISI study. Both studies project capital requirements for the period through 1988, using 1978 as the base year.

Domestic steel consumption is assumed to increase by approximately 1.5 percent per year. This is a conservative forecast, which under present economic conditions appears valid, although it is conceivable that an economic turnaround in the next few years and a period of major capital spending throughout industry could push consumption significantly higher (see ch. 5). The projected tonnages of shipped steel for 1988 and the actual tonnages for 1978 are given in table 129. There is a net increase of 17.2 million tonnes of domestic shipments during the 10-year period. It is also assumed that imports account for 15 percent of domestic consumption through 1988, as compared to 18 percent of domestic consumption in 1978. This is a critical assumption, which depends on a combination of Government policies and foreign economic conditions and choices. If appropriate condi-

[14]AISI, "Steel at the Crossroads: The American Steel Industry in the 1980's,"' 1980.

Table 129.—AISI and OTA Assumed Increases in Domestic Steel Use and Reduction in Imports, 1978 and 1988 (million tonnes of shipped steel)

	1978	1988
Domestic shipments	89	106
Exports	2	3
Imports	19	18
Domestic consumption	106	121

SOURCE Offlce of Technology Assessment

tions do not prevail, imports could rise substantially above the assumed 15-percent level before 1988 (see ch. 5).

AISI's capacity expansion figures are for net capacity increases; that is, capacity reductions at the current rate of decline (2 percent per year) are more than offset by increases stemming from the modernization program. Capacity utilization is assumed to increase from the 86.8 percent that prevailed in 1978 to an average of 90 percent in 1988. This is technically feasible, and perhaps conservative.[15] During the past 2 years, there have been sustained periods of capacity utilization well over 90 percent—during 1979, for example, the average operating rate was more than 93 percent from March through mid-July.[16] Nevertheless, 90-percent utilization of capacity would increase steel shipments by 3.3 million tonne/yr.

AISI further assumes that modernization will improve the total yield of the steelmaking process from the present 71.5 to 77 percent by 1988, which will provide another 7.1 million tonnes of shipments per year. OTA finds this assumption quite realistic if the industry substantially increases its use of continuous casting and makes other improvements. AISI assumes that continuous casting will increase from the 15-percent level in 1978 to 45 percent in 1988. OTA believes that 50-percent use of continuous casting is feasible and would increase industry yields to 76 percent.

The 10.3-million-tonne total increase in actual steel shipments obtained through replacement of facilities in the AISI analysis is attributed to neither roundout nor brownfield expansion, but rather to modernization. Personal communication with AISI personnel indicated that they refer to their modernization program as brownfield expansion accomplished in a piecemeal fashion, which leads eventually to the equivalent of construction of new plants. Four examples of the replacements in AISI's modernization program are the replacement of older blast furnaces with larger and more efficient modern ones, the replacement of all existing open hearth steelmaking furnaces with electric furnaces and basic oxygen furnaces on an equal tonnage basis, the replacement of ingot casting with continuous casting, and the replacement of one-half of existing coking capacity with new ovens. These examples do not appear to be consistent with previous use of the term "modernization' within the industry, but they are consistent with past definitions of roundout activities. '8 However, the unit capital costs of the AISI modernization program are higher than most estimates for rounding out.

Unit Capital Costs for Modernization

Data on roundout and greenfield unit capital costs for integrated plants from a number of sources in addition to AISI are given in table 130. The table shows that the average of the capital cost estimates from a number of sources is in excellent agreement with the values used by AISI, although the AISI value for roundout is higher than all but one of the other estimates. In the table all dollar figures for years prior to 1978 have been converted to 1978 dollars by the use of gross national product (GNP) implicit price deflators for nonresidential investment as provided by the U.S. Bureau of Economic Research. For both roundout and greenfield costs, there is no significant difference between estimates for 1975 and those for the past 2 or 3 years. This indicates that it is not necessary to adjust costs to take into account the increase in the steel equipment cost index, and the AISI analysis does not use such an adjustment to account for the lower purchasing power of in-

[15] *World Steel* Dynamics (April 1979) indicates that in 1978 domestic effective or available capacity was 92 percent of rated capacity, and for 1971-76 it was 95 percent.

[16] *American Metal* Market, Jan. 4, 1980, p. 3.

"''Benefits of Increased Use of Continuous Casting by the U.S. Steel Industry, " OTA technical memorandum, October 1979.

"'''While rounding out usually connotes an expansion of existing facilities, obviously' the same logic applies to modernization through replacement of facilities in place.'" (Council on Wage and Price Stability, "Prices and Costs in the U.S. Steel Industry, " October 1977.)

Table 130.—Integrated Carbon Steel Plant Capital Cost Estimates for New Shipments Capacity (1978 dollars/tonne of capacity)

Source	Year	Roundout	Greenfield
A. D. Little[a]	1975	**$628**	**$1,296**
Fordham[b]	1975	**880**	**1,474**
COWPSC	1976	**710**	**1,502**
U.S. Steel[d]	1976	NA	**1,220**
Marcus[e]	1976	630	**1,514**
Inland Steel[f]	1977	520	**956**
Mueller[g]	1978	715	**1,210**
Republic Steel[h]	1979	372	**1,367**
Average		636	**1,317**
(Standard deviation)		(160)	**(190)**
AISI[i]	1980	743	**1,287**
AISI—on actual shipment basis (90 percent of capacity)	1980	**825**	1,441

NA = Not available
aA.D. Little, "Steel and the Environment A Cost Impact Analysis," 1975, these estimates appear to Include a relatively small amount of nonintegrated mills
[b]Fordham University, "Financial Study of the U S Steel Industry," 1975
Council on Wage and price Stability, " Prices and Controls in the U S Steel In-
dIndustry Week, Apr 15, 1976, P 11
eP Marcus, 'Steeling Against Inflation, " Mitchell, Hutch Ins, May 1977
fW H Lowe, vice president for finance, "Capital Formation in the Steel Industry," *Proceedings of the Steel Industry Economics Seminar,* AISI, 1977.
gH G Mueller, "Structural Change in the International Steel Market, " Middle Tennessee State University, May 1978
hW J Delancey, C E O , *New York TimeS,* June 181979
'AISI, "Steel at the Crossroads The American Steel Industry in the 1980' s," 1980, and personal communication that *greenfield cost was $430/tonne of actual shipments and operating rate was 0.9,* and that the roundout costs although not called that are indeed of that nature even though they are listed in the expansion category

vestments during the period of the forecasting.

Comparison of Capital Cost Estimates

Capital cost estimates from a number of sources for greenfield plants of nonintegrated companies and the AISI figure for electric furnace facilities are given in table 131.* Here too, there is no indication that, other than using the GNP deflator, an adjustment is necessary due to a more severe increase in the equipment cost index. The relatively large variation among the estimates for nonintegrated steelmaker is due to rather large differences in their product mixes. In several cases, the plants have been designed to make higher grades of steels and products, and thus their capital costs are greater than

*The much lower costs in table 131 as compared to table 130 result largely from the absence of facilities to convert iron ore to metallic iron. Instead, ferrous scrap is charged to electric steel making furnaces.

Table 131 .—Capital Costs for Nonintegrated Carbon Steel Plants (Greenfield) (1978 or 1979 dollars)

	Dollars	cost (dollars per tonne capacity)	Annual product capacity (tonnes)
Fordham Univ.[a]	1978	$278	NA
Chapparal Steel Co[b]	1979	320	450,000
Huron Steel Co.[c]	1978	220	225,000
Bayou Steel Co[d]	1979	211	550,000
Raritan Steel Co.[c]	1978	207	450,000
North Star Steel Co.[e]	1979	193	350,000
Florida Steel Co.[f]	1979	157	300,000
Chapparal Steel Co.[g]	1979	165	NA
Nucor Corp.[h]	1979	154	300,000
Average		212	
AISI (apparently for broader product mix of integrated companies)[i]	1979	545	

NA = Not available
[a]Fordham Unlversity, "Financial Study of the U S Steel Industry, " 1975
bAmerican Metal *Market,* Dec 7, 1979 (for a plant to produce more complex and costly products such as plates and structural beams)
clron and Steel *Engineer,* February 1978 (for a plant to produce special quality bar products)
dIron Age, Apr 23, 1979
eAmerican Metal Market, Oct 4, 1979 (for a **plant to** produce special quality bar products)
fAmerican Metal *Market,* Nov 21, 1979
gW W Winspear, president, Chapparal Steel, September 1979
hAmerican Metal *Market,* Aug 5, 1979
IAISI, "Steel at the Crossroads The American Steel Industry in the 1980's" 1980, and personal communication that the categories of electrical furnace facility expansion corresponded to a green field plant

the traditional nonintegrated plant, which emphasizes the production of such simple products as reinforcing bar. The average cost of $21 l/tonne for the nonintegrated plants is markedly less than the AISI figure of $544/tonne.

One reason for the higher cost figures of AISI may be that they are based on electric furnace steelmaking in integrated companies. These companies generally have higher capital costs than nonintegrated companies, because they produce a broader line of products than do nonintegrated companies; this diversity requires extensive forming and finishing facilities that the electric shops of nonintegrated companies do not normally have. The AISI analysis apparently assumes that the nonintegrated companies will not expand capacity in the future; however, considering the recent rapid growth of nonintegrated steelmaker (see ch. 8), this is a questionable assumption.

Table 132 shows the unit costs and plant mix used in the AISI analysis and the equivalent figures used in the OTA scenario. For integrated and nonintegrated plants, OTA used the averages given in tables 130 and 131, and for the electric furnace facilities of integrated plants, the AISI costs. For the replacement program, OTA has also used the 25-percent electric furnace fraction in integrated plants. OTA has assumed no replacement of facilities in nonintegrated companies, because these plants account for only 10 percent of present total capacity and most are relatively new. The higher cost alloy and specialty plants are omitted explicitly in both the OTA and AISI calculations. These plants account for only about 3 percent of domestic capacity, and they have been modernizing and expanding during the past several years and appear to have excess capacity. Thus, no significant error will be introduced by excluding them from this 10-year projection and analysis.

Table 132.—Unit Capital Cost for Replacement and Expansion in Integrated and Electric Furnace (Integrated and Nonintegrated) Plants (1978 dollars per tonne)

	Replacement			Expansion			
					Greenfield		
	Integrated	EF (int.)	Average (25% EF)	Integrated roundout	EF (int.)	EF (non int.)	Average (50% EF)
AISI[b]							
Actual shipments.	$1,293	$550	$1,100	$825	$605	NA	$677
Capacity.	1,164	495	990	743	545	NA	644
OTA							
Actual.	1,320	550	1,128	708	605	$234	564[d]
Capacity.	1,188	495	1,015	638	545	211	508[d]
Actual.							459[e]
Capacity.							413[e]

NA = Not available
aUsing the AISI procedure of replacement = 0.9 X greenfield costs
bAISI, "Steel at the Crossroads The American Steel Industry in the 1980's." 1980
CActual shipments = 0.9 of shipment capaCltY
d50% nonintedgrated; 25% electric furnace Integrated; 25% intewatecf
e100% nonintegrated with the $413/tonne cost obtained as follows: assuming 50% @ $275/tonne, 25% @ $440/tonne, and 25% @ $660/tonne for plants producing higher quality/cost products on a capacity basis The justification for the $660 cost IS as follows Half IS for the steel plants and half for a direct reduction plant Beggs has forecast an increase of about 25 million tonnes of direct reduced iron in the United States by 1985 and a total of $2 billion for capital spending on direct reduction plants for the period 1980-90 Assuming that $1 billion IS used to obtain the 25 million tonnes, the capital cost per tonne of DRI IS about $330 (1978 $) It is more realistic to assume this increase in domestic DRI production and the predicted 73 million additonal tonnes of products made in electric furnaces for the 1978-88 period of the OTA forecast This corresponds approximately to about one-quarter of the additional electric furnace steelmaking using direct reduction (D Beggs, ' Issues and Answers on the Future of Direct Reduction in the U S '33 *Metal Producing,* January 1980.)

Table 133.—Eight Scenarios for Expansion and Modernization Strategies and Annual Capital Costs for Actual Shipment Increases (million tonnes/year)

	Modernization/replacement				Expansion			
	Capacity affected[a]	Cost/tonne	Cost/Year (billions of 1978$)	Net annual tonnage increase by 1988	Tonnage increase	Cost/ tonne	Cost/year (billions of 1978$)	Total annual capital costs (billions of 1978$)
AISI[b]	4.0%	$1,100	$4.4	10.3	6.9	$715	$0.5	$4.9
OTA[c]								
Scenario A	2.0	1,128	2.2	6.8	6.9 3.5	564 708	0.4 0.3	2.9
Scenario B	2.0	1,128	2.2	10.3	6.9	564	0.4	2.6
Scenario C	98.9	25	2.5	6.8	6.9 3.5	564 708	0.4 0.3	3.2
Scenario D . . .	2.0	708	1.4	6.8	6.9 3.5	564 708	0.4 0.3	2.1
Scenario E . . .	98.9	28	2.7	10.3	6.9	464	0.3	3.0
Scenario F	4.0	708	2.8	10,3	6.9	459	0.3	3.1
Temple, Barker, & Sloane, 1975-83[d]	75.3	28	2.1	0	29.9	464	1.6	3.7

aEither a small fraction of currentt capacity can be replaced at a relatively high cost per tonne, or an alternative methodology is to assume a smaller per tonne spending level on the entire capacity base

bAISI Steel at the Crossroads The American Steel Industry in the 1980' s,' 1980

cThe OTA scenarios incorporate the following assumptions

	Modernization	Expansion
A	200. replacement rate at cost Similar to AISI, operating rate at 90°. = 33 million tonne/yr yield increase = 35 millilon tonne/yr (1/2 AISI value)	69 million tonne/yr from OTA variable plant mix and 35 million tonne/yr from integrated plant roundout
B	Same as A except obtatain same 103 million tonne/yr as AISI at one-half the cost, justified on basis of costs for five types of facilities replacement	69 million tonne/yr form OTA variable plant mix
C	Based on historical spending rates a cost per average tonne of actual shipment for 1979.88 levels to A results	Same as A
D	2% replacement rate using roundout cost for Integrated plants giving results of A	Same as A
E	Cost per tonne from TBS study based on process step analysts gives AISI result (10.3 million tonne/yr)	69 million tonne/yr using TBS expansion cost
F	4% replacement rate at Integrated plant round out cost gives 10.3 million tonne/yr	69 million tonne/yr from 100% nonintegrated plant expansion

dTemple Barker and Sloane Analysis of Economic Effects of Environmental Regulations on the Integrated Iron & Steel Industries, 1977

place in both nonintegrated and integrated electric furnace steelmaking and in nonelectric integrated steelmaking (greenfield for the former and roundout for the latter). In scenario A, to compensate for the lower capacity increase from modernization, an additional expansion of capacity corresponds to more integrated roundout.

In OTA scenario C, modernization is based on a capital spending average applied to the total steelmaking capacity base, rather than some part of it; and unit capital cost of $25.3/tonne is derived from historical data. The expansion program is the same as that for scenario A.

In OTA scenario D, the modernization program is based on roundout costs for integrated plants, applied to one-half the capacity base used in the AISI analysis—this in contrast to OTA scenarios A and B, in which the higher unit costs analogous to the AISI procedure are used (i.e., based on 90 percent of greenfieId integrated costs). The expansion program is the same as in scenario A.

OTA scenario E uses the unit costs and methodology of the Temple, Barker, and Sloane (TBS) study[19] for the modernization and expansion programs.

OTA created scenario F in order to include a scenario that represents a major change in the structure of the domestic steel industry, yet a change consistent with minimal capital requirements. In this scenario, all expansion occurs in nonintegrated companies. This could happen even if the nonintegrated companies merely doubled their total annual tonnage by 1988, not an unrealistic possibility (see ch. 8). However, this rate of nonintegrated company growth would likely entail

[19] Temple, Barker, and Sloane, "Analysis of Economic Effects of Environmental Regulations on the Integrated Iron and Steel Industry," Environmental Protection Agency, July 1977.

capital cost increases for plants to make higher quality steels and more complex products; a small fraction of plants might even introduce direct reduction facilities to supplement scrap use after 1985. Thus, in this scenario unit capital costs increase from $211/tonne of shipment capacity to $412 in 1988. The modernization program is based on roundout of integrated facilities or replacement of specific facilities as discussed in the next section.

Interestingly, the total annual capital costs are quite close to each other in all six OTA scenarios, ranging from $2.1 billion to $3.2 billion per year and averaging $2.8 billion. All are less than the AISI figure of $4.9 billion per year. Scenario F is considered the most important option for the next decade.

Differences in Modernization Results

For the modernization category, an important difference between some of the OTA possibilities and the AISI approach is the unit capital cost. AISI used a relatively high modernization cost, $1,100/tonne, applied to a large base, an annual average of 98.9 million tonnes of shipments. The OTA estimates were based on lower unit costs consistent with past trends for roundout, which are lower than those for modernization. This lower unit cost is applied either to the same capacity tonnage base as is the AISI case, assuming a 4-percent replacement rate, or to half this tonnage, which results in markedly lower annual capital expense. The AISI method leads to an annual modernization cost of $4.4 billion, the largest single contribution to its estimated total annual capital needs. All the OTA modernization scenarios lead to additional capital costs of between $1.4 billion and $2.8 billion per year. While the OTA modernization program at $2.8 billion annually might suffice for the 1980's, there would be a need in the 1990's for large investment in new integrated facilities.

The lower estimates for modernization in the OTA methods are consistent with past per-tonne spending and the capacity expansion that resulted from that spending. For the past 10 years, the average annual industry capital spending on productive steelmaking (excluding regulatory costs and nonsteelmaking activities) was just over $2 billion. The industry maintains that this level of spending has been inadequate. During that period, however, very high operating rates were attained for sustained periods. Moreover, there were also very large increases in the use of continuous casting, continued replacement of open hearth furnaces with basic oxygen furnaces, and substantial increases in electric furnace steelmaking. The favorable effects these changes had on capacity were masked to some degree by the loss of capacity from closing obsolete plants. But what has evolved is more efficient capacity than before, capable of operating at higher rates with lower production costs.[20]

A more explicit way of obtaining modernization capital needs is to consider the actual costs for replacement of particular technologies and phases of steelmaking. Using several categories of technologies discussed by AISI, OTA has estimated total modernization needs for scenario F (table 134). The total for the 10-year period is $28 billion.

This total compares to $44 billion in the AISI scenario. A discussion with AISI officials and industry representatives provided detailed information on the anticipated uses of capital for the AISI scenario that was not provided in the formal AISI report. Although AISI and industry representatives agreed with categories one through four of table 134, a major difference existed for category five, replacement of finishing mills. For this use, AISI used a cost per tonne of $550 applied to

[20] The effectiveness of past capital spending has been underestimated by most analysts. For example, "The recent plant closings have created a widespread impression of general decrepitude. But the steel industry has been extensively modernized since 1960, with capital expenditures totaling $3o billion. The best proof of its health is that the industry has managed, after all, to hold on to most of the business in the world's least protected major steel market, and has survived until now without special government favors. " (E. Faltermayer, "How Made-in-America Steel Can Survive, " Fortune, Feb. 13, 1978.)

[21] Meeting on Mar. 13, 1980 with representatives of U.S. Steel Corp., Inland Steel, Bethlehem Steel, and AISI.

Errata Sheet

The reference on page 319 to table 135 was a typographical error. It should have read table 134A. Table 134A was omitted and appears below.

Table 134A. -Capital Costs for Finishing Mill Replacement, Scenario F, 1978-88

Type of finishing mill	Unit capital costs (1978$/tonne output)			percent 1978 capacity replaced[d]	Approximate average annual shipments affected[e]		10-Year capital costs for mill replacement (1978$ billions)
	Hogan[a]	TBS[b]	OTA[c]		Percent	Tonnes (10[6])	
Plate	$310	$288	$297	45	10	10	$1.3
Hot strip	95	100			17	17	.3
Cold strip	na	321	330	29	19	19	1.8
Wire rod	na	713	660[f]	17	3	3	
Galvanizing		460	462	9			.3
Heavy structural	528	561	550	15[g]	5	5	
Rod	186		220	20[g]	17	17	.8
Seamless pipe	396	514	495	15[g]	4	4	.3
Other	na	na	4409		15	16	1.4
				Total.	100	98	7.0
Weighted average		$312		22			
Assuming 75-percent facility availability y and 20-percent additional replacement		$418		26			11.0

na = not available.

aW. T. Hogan, et al., *Financial Study of the U.S. Steel Industry,* Department of Commerce, August 1975, baaed on company interview.
bAttributed to Temple, Barker, and Sloane as given in P. Marshall, Report to the Council on Wage and Price Stability, World *Steel Trade: Current* Trends and Structral Problems, Hearing, House Ways and Means Committee, Sept. 20, 1977.
cOTA has used this value to calculate costs, as baaed on data of Hogan *and* TBS end other available information.
dAmount over 25 yers old according to AISI, Steel *At The Crossroads: The American Steel Industry in the 1980's, 1980.*
eUsing product mix for 1978 se reported by AISI and rounding off.
fThis may be highly overestimated since a new wire rod steelmaker (Raritan Steel Co.) has recently constructed an entire new steel plant for approximately $220/tonne capacity, only half of which is likely to be for finishing.
gAssumed by OTA on the basis of both generally available information and confidential information from industry Sources.

Table 134.—Capital Cost Estimates for Major Facility (Technology) Replacements, 1978-88—Scenario F

Change	Approximate cost per tonne[a] (1978 $)	Approximate 1978 capacity changed (percent)	Approximate tonnage affected (annual million tonnes)	Total capital cost (billion 1978$)
1. Replacement of older, s-mall blast furnaces with larger modern ones	$110	250/.	27	$ 3
2. Replacement of open hearth furnaces with basic oxygen furnaces	55	100	18	1
3. Replacement of ingot casting with continuous casting	88	35	32	3
4. Replacement of old coke ovens with new ones	220	50	27	6
5. Replacement of old finishing mills with new ones (in integrated plants)	418	26	25	11
6. Replacement of old electric furnaces	83	33	9	1
7. Raw materials and miscellaneous	—	—	—	3
Total cost				$28

aObtained from discussions with Industry personnel news reports on plant construction, and by using data in "Analysis of Economic Effects of Environmental Regulations on the Integrated Iron and Steel Industry," Temple Barker and Sloane for EPA. 1977 (converted to 1978 dollars and rounded off)

SOURCE Off Ice of Technology Assessment

40 percent of 1978 capacity and 36.3 million tonnes. This results in spending $20 billion on finishing mills, as compared to $11 billion for scenario F.

The details of the OTA calculation of finishing mill replacement costs are given in table 135. The methodology consisted of using unit capital costs for particular types of finishing mills and specific amounts of capacity replacement based on replacing the oldest facilities, and applying these costs to the product mix reported by AISI for 1978. Adjustments were then made to compensate for 75-percent availability of finishing mill facilities and to increase replacement by 20 percent to account for facilities that would reach excessive age during the l0-year modernization period.

Of the $16 billion difference in total modernization capital needs between scenario F and the AISI scenario, $9 billion is accounted for solely by the difference in finishing mill replacement. Although there is no doubt that the greater spending by AISI would result in more new finishing mill facilities at the end of the decade, three qualifications should be noted: the AISI scenario calls for spending $2 billion annually on finishing mill replacement, a rate equal to the total capital spending on productive steelmaking facilities for the past

Table 135.—Projections of Annual Capital Needs *(1978* **dollars in billions)**

	Wyman[a] (1977)	Inland Steel[b] (1977)	U.S. Steel[c] (1978)	AISI[d] (1980)	OTA
Increase in shipments (million tonnes)					
Replacement/maintenance	$2.3	$2.2	$2.2	$4.4	$2.8
Expansion	.7	1.6	1.7	.5	.3
Regulatory compliance	1.0	**1.1**	**1.0**	*.8*	*.8*
Nonsteel	.3	.5	.4	.8	.7
Subtotal	4.3	5.4	5.3	6.5	4.6
Debt repayment/increase in working capital	.3	NA	NA	.5	.7
Total	$4.6	$5.4	$5.3	$7.0	$5.3

aJ.C. Wyman, "The Steel Industry: An American Tragedy?" Faulkner, Dawkins, and Sullivan, February 1977
bThrough mid-1980's, W H Lowe (vice president for finance, Inland Steel Corp.), "Capital Formation in the Steel Industry," *Proceedings of Steel Industry Economics Seminar,* AISI, March 1977
cThrough mid-1980's B.D. Smith (vice president and comptroller, U S Steel Corp.), "Capital Formation in the Steel Industry," proceedings "The American Steel Industry in the 1980's—The Crucial Decade, " AISI, April 1979, dollars converted to 1978 dollars by multiplying by O 87
dThrough 1988, the deflcit results from present Capital recovery periods; AISI, "Steel at the crossroads: The American Steel Industry in the 1980' s," 1980

10 years, of which only about 10 percent was spent on finishing mills; although some steelmaker have old finishing mill facilities, they are still more profitable than the industry average;[22] and the capital costs of finishing mills are probably lower today than in past years because of the availability of foreign equipment at prices considerably below those of some domestic equipment makers. The tenfold increase in purchases of finishing mills for the AISI scenario could probably not be supplied by domestic finishing mill manufacturers; extensive use would probably have to be made of foreign equipment. The average unit finishing mill cost of $550 per tonne compares to the $418 value estimated by OTA. Use of the latter cost would decrease the AISI total finishing mill replacement cost from $20 billion to $15 billion.

After differences in spending for finishing mill replacements are accounted for, the remaining $7 billion difference between the AISI scenario and scenario F results from miscellaneous replacements and raw materials facilities. Category six in table 134 is for replacement of electric steelmaking furnaces at a cost of $1 billion. AISI has indicated a total of $4 billion for miscellaneous replacement capital spending, including electric furnaces. Furthermore, AISI had indicated spending of $7 billion for replacement of raw materials facilities. Category seven in table 134 is for raw materials and miscellaneous spending with a cost of $3 billion.

OTA has found it extremely difficult to determine specific needs for raw materials facility spending. Much of the spending for this purpose is not reported by steel producers as part of their steelmaking operations, and much is by companies outside of the steel industry, such as coal and iron ore companies, and by foreign sources of imported iron ore who account for one-third of domestic ore use. Moreover, the industry has spent considerable sums in this area during the past two decades, including much for iron ore pelletizing facilities. If AISI is correct in its estimate for capital needs in the miscellaneous category including electric furnaces and OTA is correct in its estimate for electric furnace needs, this would mean that $3 billion, or 15 percent of the annual capital spending for the past 10 years, is actually needed for miscellaneous spending. In this case, the $3 billion for raw materials development in scenario F would disappear. It may be more realistic to assume that approximately $2 billion would be available for raw materials spending in scenario F. This would be equivalent to approximately 10 percent of the annual capital spending for the past decade, rather than the 35 percent of the past decade's annual spending in the AISI scenario.

In the TBS[23] study based on AISI data on plants of member companies, most of the estimates for replacement capital needs are in approximate agreement with the costs in table 134. The largest difference is for the raw materials area. Making suitable adjustments for capacity differences and other factors to make the comparison valid, the TBS study found a need for $60 million annually for raw materials, or less than 10 percent of the AISI figure and only 30 percent of the estimate of $200 million annually most likely for scenario F. The total annual capital needs for replacement over a 10-year period in the TBS study is $23 billion, compared to $28 billion in scenario F and $44 billion in the AISI scenario. In addition to having unusual access to the AISI plant operating data, which allowed a detailed process-by-process cost analysis for capital needs, a great many industry personnel were involved with the TBS study. Moreover, their analysis is based on consideration of integrated plants only and extrapolation of this to the entire steel industry. Hence, the effect of noninintegrated companies' lower costs is not factored in.

With the level of spending for modernization in scenario F, the replacement cycle for

[22] For example, Inland Steel Co., generally recognized to be the most profitable large integrated producer, has some very old finishing mills. Two of its three hot strip mills are over 40 years old, and the average age for its four cold strip mills is 22 years, (*World Steel* Industry Data Handbook—The *United* States, McGraw-Hill, 1978.)

[23] Temple, Barker, and Sloane, op. cit,

steelmaking facilities can be calculated. The cycle is obtained by dividing the capital cost per tonne of annual shipment by the annual capital expenditure. With capital spending of $2.8 billion annually, the annual spending per tonne of shipments equals $25, which is the industry average for 1969-78. There is greater uncertainty as to the correct cost for the replacement of shipment capacity. AISI uses a cost which is 90 percent of the capital cost for constructing a new, greenfield facility. On this basis, scenario F leads to a replacement cycle of 37 years, * compared to 30 years for the industry during 1959-68, 40 years for 1969-78, (an average of 35 years for the 20-year period), and 25 years for the AISI scenario. However, OTA cannot find any specific way of justifying the use of the 90-percent figure in obtaining the replacement capital cost. Considering the value of many elements of existing plants that would continue to be used, as well as the scrap value of facilities removed, it is likely that average replacement capital costs would be less than 90 percent of greenfield costs; other analysts have estimated the ratio of replacement to greenfield costs to be 67 percent" or even as low as 45 percent.[25] For scenario F, if the ratio is 80 percent then the replacement cycle is 33 years. for 75 percent the cycle is 31 years, and for 67 percent it is 27 years.

In any event, the utility and relevance of using the facility replacement cycle are not beyond criticism. Using average industry costs and average industry age does not accurately describe the process of replacing portions of existing plants. Each type of equipment is likely to have a different maximum lifetime during which it performs at design efficiency, and a different age because of prior replacement and modernization. Current facilities, although relatively old, may have costs that still allow acceptable profit levels. * Advancing technology also limits the usefulness of average age: the age at which specific types of equipment become obsolete can increase, depending on the original choices regarding design and construction, or decrease, depending on the advent of radical new technology. Age may also be an invalid indicator of the need to replace because, more often than not, the facilities have not been operated at full or rated capacity for the entire chronological period corresponding to age. Furthermore, the quality of labor practices combined with increasing use of computer control can reduce the wear and tear on facilities and extend their useful lives,

Nevertheless, it is pertinent to evaluate what the AISI modernization capital needs would be on the assumption that the replacement rate is kept at 4 percent, but the unit cost is reduced from the assumed 90 percent of greenfield costs to a lower value. The result for a 75-percent figure is that modernization capital needs decrease from $4.4 billion annually to $3.7 billion. The $2.8 billion annual spending of scenario F would be obtained if replacement costs are 57 percent of greenfield costs, which seems reasonable based on the estimates cited above, assuming an increase in market share for the lower capital cost nonintegrated producers.[26]

*The calculation is based on using the integrated replacement cost of $1,129 tonne for 87 percent of the industry and the greenfield cost for nonintegrated plants of $234/tonne for 13 percent of the industry.

[24]P. Marshall, report to the Council on Wage and Price Stability, "World Steel Trade: Current Trends and Structural Problems," hearing of the House Committee on Ways and Means, Sept. 20, 1977.

[25]W. T. Hogan, et al., "Financial Study of the U.S. Steel Industry," U.S. Department of Commerce, August 1975.

*The situation is analogous to an old automobile which has had many of its critical components replaced at different times. How useful is it to describe the automobile as, for example, 30 years old, if it is still functioning in an acceptable manner? It may still be less costly to replace parts rather than replace the entire automobile. The situation changes dramatically when a major technological innovation occurs for a component that is not compatible with the other, older components.

[26]See especially Marshall, op. cit. Assuming a growth of nonintegrated company market share from 13 to 25 percent for the 10-year period, greenfield integrated costs of $ 1,253/tonne, and a 4-percent replacement rate, Marshall's 67-percent ratio of replacement to green field costs leads to an annual replacement cost of $2.9 billion. Using his 67-percent figure and the slightly lower AISI unit cost of $1, 100/tonne and replacement rate of 3.25 percent, the annual cost of replacement would be $2.6 billion.

Differences in Expansion Results

OTA used lower unit costs than AISI for capacity expansion, based on roundout costs that are historically lower than greenfield costs for integrated plants. Moreover, OTA has assumed the continued growth of the non-integrated electric furnace segment and factored in their low capital costs in the total for capacity expansion. When OTA assumed less capacity increase from modernization, capacity was assumed to increase by an identical amount through roundout expansion of integrated plants. In scenario F, capacity expands as much as assumed by AISI, but entirely through greenfield construction of non-integrated plants (at greater unit cost because of product-line expansion). This does not imply that integrated capacity does not expand, only that it does so by means of roundout rather than greenfield construction.

Neither the AISI study nor the OTA scenarios incorporate any greenfield construction of integrated plants, although the AISI modernization costs are 90 percent of greenfield integrated unit costs. As previously noted, a consensus exists that integrated greenfield construction cannot be justified because of the higher costs and higher prices it would entail (see table 128). The implicit assumption in the AISI analysis is that major changes in Government policy, such as allowing faster capital recovery, will enable the industry to spend at the high levels proposed in their scenarios.

Differences in Lower Spending Scenarios

There is another part of the AISI analysis (designated as their scenario 11) which is a continuation of current trends. The annual cost for productive steelmaking investment is given as $3 billion. Although the spending level is the same as OTA scenario F, the anticipated results differ. AISI asserts that this level of investment would lead to maintenance of existing production capability and the same average equipment age if the unit cost is just under $1,100/tome (the figure used in their high replacement scenario summarized in table 133). That is, the replacement rate is under 2 percent but there is no improvement in production capacity resulting from improved operating rate or increased yield. However, it is also suggested that up to 20 percent of production capacity would be eliminated because of low profitability.

This scenario seems questionable in view of the experience and results within the industry during the past decade, when annual spending was at the $2 billion level. While a loss in capacity has occurred during the past decade, the ability to produce more steel from the remaining capacity appears to have actually increased, This is because the most obsolete facilities have been closed, and substantial modernization was obtained at the $2 billion per year level.

Total Capital Needs and Shortfalls

Capital Needs

To understand the significance of these capital cost calculations and of the difference between the OTA and AISI estimates, it is necessary to examine the steel industry's total capital needs. Summaries of the AISI estimates and three earlier industry projections of capital needs, as well as OTA findings, are given in table 135. OTA projects capital requirements for modernization and expansion at $3 billion annually; although this finding corresponds to OTA scenario F, it is representative of the range for all the OTA scenarios. OTA concurs with the AISI estimate for the costs of compliance with Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations, $0.8 billion annually, although OTA believes that toward the end of the period OSHA-related costs will tend to be greater than the annual $0.1 billion assumed by AISI; but this difference should be offset by declining EPA-related costs.

On the basis of unpublished survey data, AISI projected that $800 million would be needed annually to finance nonsteel diversification. OTA put this amount at $700 million because it is more consistent with the trend of the past decade. Barnett of AISI, on the grounds that 22 percent of the capital spent on productive steelmaking facilities has been spent on nonsteel activities, concludes that this need will absorb $660 million a year. As shown in table 135, previous estimates for nonsteel spending range from $300 million to $500 million annually. '

Adding in the amounts needed for increases in working capital—$().7 billion by OTA estimate, as compared to AISI's $0.5 billion annually—AISI arrives at a total capital requirement of $7.0 billion annually, while the OTA scenarios find a total need of $5.3 billion per year between 1978 and 1988. The OTA total agrees with 1978 industry estimates of $5.4 billion and $5.3 billion, as well as a 1977 estimate of $4.6 billion by a Wall Street analyst. "

*There are no data to support a trend of increasing diversification of steel companies, but attention to such diversification has been increasing. Analysis of company annual reports and Securities and Exchange Commission 10-K reports reveals vastly different diversification activities, from nearly none for some companies to very considerable levels for others, Neither is there an apparent link between diversification and steel profitability. Nevertheless, the argument is often made that diversification absorbs capital needed for steelmaking modernization and expansion. The industry's position is that profitable diversification provides a positive cash flow, which supports less profitable steelmaking investments. Moreover. diversification provides stability to the normally cyclic steel business. A steel industry modernization and expansion program that improves profitability could reduce interest in and need for diversification.

Capital Availability

The AISI study did not provide a detailed analysis of capital formation and cash flow in the steel industry. Personal discussion with AISI officials has revealed that the deficit under the existing laws would be $2.3 billion annually. Table 136 compares results for the OTA scenario with an earlier analysis and with an actual 1978 cash flow and cash use as derived from official AISI information for 1978.

Net income has been adjusted upwards in order to be consistent with the assumed increase in shipments for the 1978-88 period. Income as a percentage of revenues was at first held to the 1978 level of 2.8 percent, but this cannot be the case if the modernization and expansion program reduces production costs was assumed, which added $225 million

'-Wyman, op. cit.

Table 136.—Average Annual Capital Sources and Uses (1978 dollars in millions)

	Wyman (1977)'	Industry actual 1978[b]	OTA scenario
Aftertax profit (including deferred taxes).	$2,100	$1,452	$1,871'
Depreciation, depletion.	1,600	2,258	3,100
Increase in long-term debt.	600		451[d]
Cash dividends.	(800)	(598)	(650)
Net cash flow	3,500	3,112	4,772
Capital expenditures	4,300	2,852	4,600
Debt repayment and increase in working capital	**300**	**260**	**746'**
Cash use	4,600	3,112	5,146
Deficit	1,100	0	574

aJ.C. Wyman, "The Steel Industry An American Tragedy ?" Faulkner, Dawkins, and Sullivan, February 1977; depredation times were greater in 1977 than now
bAISI data (Annual Statistical Report—1!376) for companies representing 88.8 percent of domestic raw steel production have been converted to all industry figures by dividing by 089
CAssuming as does AISI, an average annual domestic shipment level of 991 million tonnes. and that prices and sleel/nonsteel contributions are the same as 1978, yields total revenues of $58.8 billion if net income as a percent of revenues is the same as 1978 (2 8 percent) then profit (net income) is $1,646,000
dIf the stockholder's equity is assumed to increase (in constant dollars) at 1 percent per year, then the midterm equity increases to $20.788 million as compared to $19,779 million for 1978, and maintaining a debt-to-equity ratio of 44% provides an increase of $451 million
eIncrease in working capital is approximated by taking 13 percent of increase In total steel sales

to the aftertax profit of $1,646 million (based on 1978 profitability). The issue of cost savings is discussed further in the next section.

The increase in depreciation results from the rising level of capital spending during the period, but present capital recovery rates have been assumed. The increase in long-term debt has been calculated by assuming that part of the increased capital spending and modernization of the industry will be financed by a small increase in stockholder's equity, and then applying the same debt-to-equity ratio of 44 percent that existed in 1978. The average total net cash flow of $4.5 billion represents these three items minus stock dividends, which have been increased over the 1978 level by approximately 10 percent.

The issue of dividends and their relative constancy regardless of performance (see ch. 4) is linked to the question of the potential for forming more capital through new equities. The industry usually maintains that it keeps dividends at relatively high levels, even though profitability is low and perhaps declining, in order to maintain stock prices. Despite this policy, however, the performance of most steel company stocks, with the exception of those of some of the nonintegrated and alloy / specialty companies, has not been good. Data on real dollar trends for several of the major steel companies are given in table 137. Real net income has fallen substantially during the past 10 years, and real return on common stock has decreased even more. The real cost of goods sold has risen more than the real value of sales.

To illustrate the relationship of dividends to performance, it is instructive to examine the best and worst performing major steelmaker, Inland and U.S. Steel, respectively. The comparison in constant dollars will be made for 1979 versus 1974, both years being in the "up" business cycles for the domestic steel industry. For Inland Steel earnings per share decreased 47 percent and dividends decreased 30 percent; for U.S. Steel earnings per share declined by 130 percent but dividends dropped by only 26 percent. Interestingly, the most diversified major steelmaker, Armco, shows the least drop in earnings per share at 27 percent, with exactly the same decline in dividends per share. Armco generally has the best economic performance as well, for example in terms of net income as a percent of sales. This is due to its diversification, since data on its steelmaking operations show it to be less profitable than Inland Steel. Thus, there is a linkage between profitability and diversification on the one hand, and dividends which accurately reflect economic performance on the other.

Many analysts have concluded that it is highly improbable that new equity issues

Table 137.—1968-79 Real Dollar Changes in Profitability and Common Stock Performance for Selected Steel Companies

Company[a]	Real growth of net income (percent/year)	Change in 1979/68 real return on common stock (percent)	Real growth of sales (percent/year)	Real growth of cost of goods sold (percent/year)
Bethlehem Steel	-13.87	– 48.00	2.18	2.92
National Steel	– 2.80	– 45.84	5.60	6.49
Republic Steel	-1.87	– 59.79	3.16	3.95
U.S. Steel	**– 0.13**	**– 39.06**	**3.04**	**3.76**
Armco[b]	2.29	11.77	5.03	5.59
Average of 100 largest U.S. industrial corporations	4.75	– 25.54	6.16	6.63

aThese Companies represent 56.4 percent of 1978 domestic shipments.
bArmco is the most diversified of the major domestic steelmakers.

SOURCE Interactive Data Corp., Washington, D.C.

would be successful, except for the noninte-grated and alloy / specialty companies with excellent records of growth and profitability. It is plausible, however, that the prospect of a major modernization and expansion program, facilitated in part by supportive Government policies, would allow dividends to be reduced and the funds to be used to help finance modernization and expansion. The perception of greatly improved future earnings might not only prevent any dramatic decline in stock prices, but actually increase investor interest in obtaining capital appreciation rather than income. In such a scenario, new equity issues might be successful; the key factor would be coupling dividend reduction with major investment in cost-cutting new technology for the future.

Capital Shortfalls in the OTA Scenario

In the OTA scenarios, the total cash the steel industry would need to finance capital expenditures for modernization and expansion, plus the increase in working capital, amounts to **$5.3** billion annually for 1979-88. At the same profitability levels as 1978, the industry would be about $600 million per year short of this requirement. This is considerably less than the deficits projected by industry analyses. If modernization and expansion reduced total costs by an average of 2 percent[28] for the lo-year period, then about $900 million would ultimately be added to the annual net income, even after taking into account the rise in financial costs caused by the debt increase, Return on equity would then increase to about 12 percent.

A policy option of accelerating depreciation, which is discussed in chapter 2, could provide enough additional income to finance the $600 million per year deficit in the OTA scenario. If, in addition to such an increase in cash flow, production costs are assumed reduced by 2 percent in the OTA modernization program, then return on equity would be close to 15 percent and return on sales about 5 percent. These returns would bring the steel industry up to the average for all domestic manufacturing.

[28] The 2-percent reduction in total costs is conservative. The future saving for continuous casting alone should give a 5-percent cost saving when replacing ingot casting. (OTA, "Benefits of Increased Use of Continuous Casting, " technical memorandum, October 1979.) For the newest integrated mill in North America, the Steel Co. of Canada projects that efficiencies of new technology will produce a cost savings of 15 to 20 percent, and of that amount, 10 percent will result from continuous casting. (American *Metal* Market, Feb. 29, 1980.) Applying a 5-percent cost savings for continuous casting to an increased adoption by 35 percent of the industry yields a 2-percent saving for the whole industry. Crandall has suggested a 3-percent saving ''if all opportunities were exploited in the very near future, (R. W. Crandall, "Competition and 'Dumping' in the U.S. Steel Market," Challenge, July-August 1978). Gold's analysis of the COWPS study suggests an 8-percent saving in operating costs, which would have to be reduced by increased financial costs. (B. Gold, "Steel Technologists and Costs in the U.S. and Japan, " Iron *and Steel* Engineer, April 1978.) AISI's analysis includes a potential savings in operating costs of 30 percent and in total costs of 15 percent after 25 years of the capital spending program already discussed. There is a lag between capital spending and realized cast savings. Thus, the 2-percent saving used here appears reasonable for the first 10 years of the program.

International Capital Cost Competitiveness

The lower capital costs in foreign steel industries have long been used to impugn the rate of technological innovation by the domestic steel industry. Japan's post-World War II success in steel has often been linked to its low capital costs:

> At an annual average cost of $1.2 billion, it meant a dramatic capacity expansion from 28 million tons at the end of 1960 to 115 million tons at the end of 1970. The expansion of 87 million tons compares to an estimated net expansion of around 20 million tons in the U.S. and Canada. For an annual average expenditure of $1.2 billion, Japan bought itself about 4.5 times as much added capacity as the U.S. and Canada did for an expenditure of $1.8 billion. [29]

[29] Wyman, op. cit.

One factor in this has been that steel mill construction costs in Japan have been less than 40 percent of U.S. levels, for which the following reasons have been given:[30]

- lower wage and price levels in Japan, which result in cheaper building materials and equipment as well as lower wages for construction workers;
- cost analysis on a facility basis, rather than on the basis of entire plants or projects;
- faster construction times because there is less labor trouble and because steel companies, rather than general contractors or consultants, supervise all or most construction;
- constant capacity improvement after, as well as before, installation of equipment; and
- use of larger economy-of-scale designs.

The following additional factors also help to explain lower Japanese costs:[31]

- an overvalued dollar vis-a-vis the yen during the postwar period;
- coastal locations, which eliminate many infrastructure expenditures;
- the absence of raw material resources, which led to imports rather than construction of raw material processing facilities for or in integrated plants; and
- rationalization of the entire industry through cooperation between banks, industry, and government, which prevented competing steel companies from duplicating facilities, notably high-cost finishing mills.

It is generally accepted that the dollar difference between Japanese and U.S. capital costs has been decreasing. In part, this is because labor costs are increasing more rapidly in Japan than here, because the value of the dollar is declining, and because domestic companies are increasing their use of foreign sources of equipment and consultation. Table 138 provides some recent data that illustrate the diminishing difference between Japanese and American capital costs, and also compares costs for a typical developing nation. It shows a 27-percent advantage to Japan over the United States, and a 27-percent advantage to the United States over the developing nation for a greenfield integrated plant. This last difference may be greater, because most developing nations usually have a substantial lack of basic industrial infrastructure.”

Table 138.—Estimates of Capital Costs for the United States, Japan, and a Developing Nation
(1978 dollars per tonne of product capacity)

	Brownfield or roundout additions to integrated plant	Green field integrated plant
United States	$715	$1,210
Japan	660	880
Developing nation	880	1,540

SOURCE H.G. Mueller, ‘(Structural Change in the International Steel Market, ” Middle Tennessee State University, May 1978

A comparison of the 1976 capital cost of similar items of steel plant equipment in different countries—correcting for differences in plant size and design and for differences in construction cost, and based on prevailing exchange rates—reveals that the United States has the highest capital costs, Europe’s are in the middle, and Japan has the lowest. Western Europe enjoys 22-percent lower costs than the United States, while Japan’s are 41 percent lower.[33]

Aylen’s analysis of American, British, and West German capital costs[34] has led him to the following conclusions regarding the cap-

‘(’Gold, op. cit.

''Wyman (op. cit.) provides an interesting analysis of the relationship between low domestic capital spending during the past several decades and the monetary policy of the United States. An overvalued dollar, he believes, forced U.S. capital spending overseas and has led to a ‘‘dismantling” of domestic industry. ‘‘While ‘dismantling” its basic industry, the U.S. “created’ a high technology base.''

[32]A recent analysis has indicated that actual costs for greenfield steel plants in developing nations are twice the original estimates. (Iron & Steelmaker, December 1979, p. 37,)

''A. J. Jarvis, “Inflation and Capital Investment in the United Kingdom, ” transactions of the 5th International Cost Engineering Congress, Utrecht, November 1978.

“J. Aylen, “Innovation, Plant Size and Performance: A Comparison of the American, British and German Steel Industries, ” Atlantic Economics Conference, October 1979.

ital spending and costs of domestic steelmaker:

> . . . the recognized investment series for U.S. iron and steel from the Bureau of Economic Analysis or the American Iron and Steel Institute overstate steel industry capital spending on plant and equipment by as much as 180 or 190 percent when compared with European levels, owing to the combined effect of a broader definition of steel industry activities, which include diversified activities, and the relatively high cost of steel plant in America.

With regard to the generally low level of U.S. capital spending (described in ch. 4) and its impact on technology choice, Aylen notes that:

> The higher cost of steel plants in the U.S. provides one explanation as to why the industry has invested at a relatively low rate per ton. High capital costs encourage substitution of other factors of production for capital. In contrast to its absolute capital cost disadvantage, the American steel industry has an absolute energy cost advantage. The American steelmaker has a stronger incentive than his European counterparts to hang on to old, energy-intensive processes such as open hearth steelmaking, poor technology blast furnaces, and conventional casting facilities.

Aylen adds, moreover, that because of the impact of capital improvements on other inputs, the full impact of capital cost differences among nations goes beyond the actual contribution of capital costs to fixed steelmaking costs:

> Admittedly capital costs per se might not introduce much absolute cost difference between steelmaker. But they do induce differences in investment behaviors with long run implications for overall factor productivity and unit costs.

Using a hypothetical reduction of 20 to 30 percent in U.S. capital costs for steel plants, Aylen simulated the effect of having capital costs similar to those in Europe. He found that from $2.9 billion to $4.8 billion would have been generated from 1960 to 1978, or the equivalent of an extra 2 to 3 years" investment at average annual rates. He concludes that, with replacement and roundout, the United States could have obtained an additional 11.3 million tonnes of raw steel capacity, or 8.6 million tonnes of actual shipments. "Such extra marginal investment would have been sufficient to improve innovation rates and raise plant size in the American steel industry to average OECD [Organization for Economic Cooperation and Development] standards. "

Aylen puts the capital investment of the domestic steel industry in perspective and deals fairly and succinctly with the criticism it has often received:

> .,. the American steel industry's failure to invest and innovate can be seen as a perfectly rational response to prevailing factor prices, rather than evidence of any inherent inefficiency. This is not to say that the steel industry should not bear part of the blame for the high costs of plants. Why must the industry order such lavish plants by Europen standards? Why have steel producers not been tougher clients when dealing with plant suppliers? Why does the industry not buy certain items of equipment more widely from European or Japanese plant suppliers?

Although importing steelmaking equipment is clearly detrimental to the balance of payments and to the welfare of domestic equipment manufacturers, it might be preferable in the long term to losing substantial domestic steelmaking capacity, with a concomitant increase in steel imports.

In conclusion, there is a distinct difference in capital cost competitiveness between the domestic and foreign steel industries. This could be remedied in the future by:

- making more steel in nonintegrated companies that use simpler, less costly equipment, and whose capacity utilization rate would be very great (see ch. 8);
- using more lower cost foreign-designed and foreign-manufactured equipment;
- using more economy-designed and economy-priced equipment in integrated plants;
- putting more pressure on equipment

manufacturers and design, engineering, and consulting firms to achieve lower costs; and

- undertaking more in-house equipment design and construction.

Radical, long-term changes in steelmaking may also bring reductions in capital costs. If domestic steelmaker take the lead in these developments, it will increase the likelihood that the necessary capital equipment will be manufactured in this country.